Original Research Article

Indoor air quality and risks connected to laundry operations in Ibadan Metropolis, Nigeria

Abstract

During washing, ironing, and dyeing, laundry workers are exposed to chemicals that could be damaging to their health and the environment. These chemicals can cause everything from throat and skin irritation to cancer. Information on indoor air quality (IAQ) in laundry environments in underdeveloped nations, particularly Nigeria, was scarce. As a result, the study evaluated the risks to indoor air quality related with laundry activities in the Nigerian metropolis of Ibadan.

In Ibadan North (IBN), Ibadan North-East (IBNE), Ibadan South-West (IBSW), Ibadan North-West (IBNW), and Ibadan South-East (IBSE), 50 out of 100 consenting laundry operators were randomly chosen to participate in a descriptive cross-sectional survey.

Multi Testers N21FR were used to monitor temperature and relative humidity (RH). Using a Met One GT 321, CO_2 meter, and an air sampler, the IAQ parameters were tracked. The values obtained for all parameters were compared to WHO limits of (Temp) 26°C, RH 60%, (PM10) 50g/m^3, (TBC) 5x10^2 CFU/m^3, and (CO_2) 1,000ppm (ASHRAE) every day for eight weeks. With SPSS (version 20), Chi-square, Pearson Correlation, and p0.05, descriptive statistics were used to analyze the data.

Both the mean indoor and outdoor total bacterial counts (TBC) CFU/m^3 values were much lower than the WHO-recommended guideline limit of 5x10^2 CFU/m^3. While indoor RH and temperature were above WHO guideline levels, PM_{10} and CO_2 were below WHO and ASHRAE guideline levels, respectively, and TBC and TFC were within WHO guideline limits in all research locations. Therefore, it is recommended to boost cross ventilations in the laundry rooms to improve indoor air quality.

IAQ appeared to be impaired in the laundry environment in Ibadan, Nigeria. To better maintain thermal comfort parameters and lower levels of chemical pollutants released by launderers and product use during services, mechanical ventilation systems in laundry environments need to be upgraded with regard to operation and maintenance.

Keywords: Indoor air quality, Health hazard, Laundry

1.0 INTRODUCTION

A fundamental need for life is clean air [1]. For life to exist, we need air. To improve human health, clean air is necessary. Human activity within the structure and the surrounding outdoor air's natural composition both have the potential to degrade and pollute the indoor air quality. There are a number of health effects of air pollution, ranging from minor to major symptoms. If exposed to contaminated air, building occupants have a significant danger of breathing in filthy air.

In Nigeria, there was an incident where families passed away over night as a result of generator fumes. Because indoor air quality deterioration results in acute exposure to air contaminants in a small space, indoor air quantity is extremely important.

Without air, all living things would perish. Air is a vital component of life. For good health, you need clean air. Due to the fact that the majority of human activities take place in structures like workplaces, schools, restaurants, houses, and so forth, this has become a global concern.

To promote healthy living, it is important to maintain the air quality in all buildings, including laundry facilities. All people are at risk for health problems from indoor air pollution, but the severity varies by age, sex, physiological state, and genetic inclination. Indoor air pollution typically results from pollution in the surrounding external air, in building materials, and from inside-the-building activities [2]. The importance of ventilation in a building has a significant impact on how bad the air pollution is. Health problems linked to indoor air pollution include headaches, dizziness, coughing, nasal congestion, wheezing, and lung illnesses [3]. According to a report, developing nations are more likely to experience poor indoor air quality due to inadequate ventilation systems in the majority of households and buildings and ineffective cooking equipment [2].

An increasing amount of scientific research over the past few years has shown that indoor air pollution can be worse than outside air pollution, even in the biggest and most industrialized cities [3]. This is true even for homes and other buildings. According to additional study, most people spend their time indoors [2]—about 90% of the time. Since many people are exposed to air pollution indoors rather than outdoors, there may be greater health hazards as a result.

The consequences of indoor air pollution are frequently most severe in those who may be exposed to it for the longest periods of time. Young people, the elderly, and those who are chronically ill particularly those with respiratory or cardiovascular conditions—come under this category [2].

The world nowadays is becoming more and more concerned with indoor air quality (IAQ). In fact, even the sheer presence of people in a structure can have a big impact on the air quality inside. A key factor in determining a healthy life and people's well-being is the air quality in homes, offices, schools, laundry facilities, public buildings, health care facilities, and other private and public buildings where people spend a significant portion of their time [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15]. When assessing the health risks of a work environment, occupational health care must frequently take indoor air quality issues into account.

The health of employees, the social climate at work, and productivity in offices, on the other hand, are all enhanced by good indoor air quality. [16, 17, 18]. According to reports, up to 30% of workers in newly constructed or refurbished buildings made an exceptionally high number of complaints about their working conditions, leading some to label the structures as "sick" [19]. Thus, it seemed that this was a concern, particularly in the colder countries. Working in these problematic buildings may result in the sick building syndrome (SBS) symptoms of a stuffy and itchy nose, rhinitis, cough, sore throat, and shortness of breath as well as skin complaints, exhaustion, headaches, and fever. [20, 21, and 22].

In many buildings, poor indoor air quality is primarily caused by indoor pollution sources that release gases or particles into the air. Due to insufficient outdoor air infiltration to balance indoor emissions and insufficient air movement to remove indoor air pollutants from the area, inadequate ventilation in laundry environments can raise indoor pollutant levels. Pollutant concentrations can also rise when the temperature and humidity are high.

The negative health impacts of indoor air pollution on people might range from mild sensory annoyance or discomfort to serious health damage. Therefore, it is crucial to evaluate the indoor air quality and risks connected to laundry activities in the Nigerian metropolis of Ibadan.

1.1 MAIN OBJECTIVE

To assess the indoor air quality and risks connected to laundry operations in Ibadan Metropolis, Nigeria.

1.3 SPECIFIC OBJECTIVES

1. To assess the indoor air quality (IAQ) of laundries in the designated five local government areas in the city of Ibadan.

2. To compare the measured indoor air quality (IAQ) of the chosen laundries to the standards set by the WHO, UNEPA, ASHRAE, HKEPD, and NHMRC.

3. To suggest a remedy for the issues with indoor air quality (IAQ) in laundry settings.

2.0 MATERIALS AND METHODS

2.1 STUDY AREA

Ibadan was the study location. Ibadan, the largest metropolis of indigenous people in West Africa, is situated in the southern region of Nigeria's Oyo State. Ibadan North, Ibadan North-East, Ibadan North-West, Ibadan South-East, and Ibadan South West all have significant populations in the city's center. According to 2006 census data, there are 1 338 659 LGAs, each of which has a 128 km^2 area.

Ibadan's latitude is 7.376736, and its longitude is 3.939786. Ibadan, the capital of Oyo State, is situated in Nigeria's Cities location category at 7° 22' 36.2496"N and 3° 56' 23.2296"E on the global positioning system. The climate in Ibadan is tropical wet and dry, with a long wet season and fairly stable temperatures all year round. The wet season in Ibadan lasts from March to October, with a little decrease in precipitation in August [23 and 24].

2.2 DESCRIPTION OF SAMPLING LOCATIONS

Ibadan metropolis were chosen because laundry works is prominent in the area. Purposefully chosen from each local government area were twenty (20) laundry homes with ten (10) people each. In total, this resulted in 100 laundry homes and one thousand (1000) individuals from five Local Government districts. The questionnaire was completed by 5 randomly chosen respondents from each of the laundry houses (a total of 100 respondents).

2.3 DATA COLLECTION

Four methods of data collection were used in the study: laboratory analysis, statistical methods (data management and statistical analysis), survey (administration of questionnaires and observational checklists), and air quality monitoring (particulate matter, temperature, relative humidity, CO_2, microbial load). Using Multi Testers N21FR, relative humidity (RH) and temperature were measured. Using a Met One GT 321, a CO_2 meter, and an air sampler, the IAQ parameters of particulate matter (PM10) concentration, carbon dioxide (CO_2), airborne total bacterial count (TBC), and total fungi count (TFC) were each calculated. The measurements were taken both in the morning and afternoon for four weeks and the means values of each parameters were calculated. The obtained values for temperature, RH, PM10, TBC, and CO_2 were compared to the WHO limits of 26°C, 60%, 50 g/m3, and 5 x 10^2 CFU/m^3, as well as 1,000 ppm (ASHRAE).

2.4 DATA MANAGEMENT AND STATISTICAL ANALYSIS

Using descriptive statistics with SPSS (version 20), Pearson Correlation, and Chi-square at p0.05, data was entered and examined. To summarize the data, descriptive statistics were employed. For morning and afternoon measurements, mean, standard deviation (SD), and range were calculated for temperature, relative humidity (RH), particulate matter (PM10), microbial burden, and carbon dioxide (CO2), and they were compared to WHO recommendations of 26°C, 60%, 50g/m3, 5x102 CFU/m3, and 1,000ppm, respectively.

3.0 RESULTS AND DISCUSSION

Here, the research project's results were disseminated, and the part also included explanations based on the findings.

3.1 METEOROLOGICAL PARAMETERS OF INDOOR AND OUTDOOR AIR QUALITY OF THE SELECTED LAUNDRIES

3.1.1 RELATIVE HUMIDITY (%).

In Table 1, the relative humidity measurements for the chosen laundry homes' indoor and outdoor spaces are shown. The WHO, the Clean Air Act (CAA) of the United

Nations of Environmental Protection Agency (UNEPA), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) recommended guideline limit of 60% were all exceeded by the mean relative humidity values for both the indoor and outdoor air.

3.1.2 TEMPERATURE READINGS (^{0}C).

The results of the indoor and outdoor temperatures in the chosen laundry houses are shown in Table.2. Both the indoor and outdoor mean temperatures (0C) were higher than those recommended by the WHO, the Clean Air Act (CAA) of the United Nations Environmental Protection Agency (UNEPA), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC).

3.1.3 AIR CO_2 CONCENTRATION (PPM).

Table 3 displays the results of the indoor and outdoor CO_2 concentrations for the chosen laundry houses. The mean CO_2 concentrations (ppm) indoors and outdoors were both substantially lower than the recommended ASHRAE limits of 1000ppm.

3.1.4 INDOOR CONCENTRATION OF PARTICULATE MATTER

Table 4 shows the average indoor PM10 measurements (in g/m3) for morning and afternoon hours in the chosen local governments. The WHO, the Clean Air Act (CAA) of the United Nations of Environmental Protection Agency (UNEPA), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong

Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) recommendation guideline limit of 50 g/m^3 were all significantly lower than the indoor and outdoor mean PM10 (g/m^3) values.

Table.1: Mean Indoor and Outdoor Relative Humidity (%) across the five local governments (%)

Location		Air Relative Humidity (%)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	52.6	78.0	67.5±6.8	60.1	78.8	66.7±6.7	60
	Ibadan Northwest	56.1	75.1	64.9±6.0	63.3	77.9	68.8±4.4	
	Ibadan Northeast	60.8	70.8	65.5±3.5	63.2	75.6	68.3±4.2	
	Ibadan Southwest	62.7	75.6	68.7±4.0	62.5	77.0	69.2±4.5	
	Ibadan Southeast	59.0	69.0	64.9±3.2	60.9	75.1	66.3±4.2	
Outdoor	Ibadan North	58.2	77.2	66.5±5.9	55.2	63.0	60.7±2.4	
	Ibadan Northwest	59.2	73.3	66.4±3.6	58.2	69.1	65.6±3.9	
	Ibadan Northeast	55.7	77.8	66.8±5.4	57.4	68.6	64.5±3.9	
	Ibadan Southwest	58.0	78.0	67.5±6.5	57.1	68.6	62.8±3.7	
	Ibadan Southeast	57.9	75.8	66.1±4.5	55.6	66.9	62.4±4.0	

Table.2: Mean Indoor and Outdoor Temperature Readings across the five local governments (^{0}C)

	Location	Indoor air temperature(^{0}C)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	*24.8*	*33.7*	*27.4±2.5*	*25.5*	*34.2*	*28.2±2.4*	26
	Ibadan Northwest	*23.4*	*32.9*	*26.8±2.6*	*26.8*	*33.8*	*28.4±2.1*	
	Ibadan Northeast	*24.6*	*31.2*	*27.5±2.0*	*24.0*	*30.0*	*27.1±2.3*	
	Ibadan Southwest	*24.8*	*33.0*	*27.6±2.3*	*26.7*	*33.0*	*28.4±1.8*	
	Ibadan Southeast	*24.5*	*29.5*	*27.6±1.5*	*25.1*	*29.9*	*27.8±1.4*	
Outdoor	Ibadan North	*23.8*	*33.9*	*26.1±2.8*	*25.9*	*33.6*	*27.6±2.3*	
	Ibadan Northwest	*25.5*	*33.7*	*26.8±2.4*	*27.4*	*34.2*	*28.7±2.0*	
	Ibadan Northeast	*24.6*	*31.2*	*27.5±2.0*	*24.0*	*30.0*	*27.1±2.3*	
	Ibadan Southwest	*24.8*	*33.2*	27.1±2.5	*26.2*	*36.3*	*29.1±2.8*	
	Ibadan Southeast	*23.0*	*30.0*	*26.0±2.4*	*23.9*	*28.1*	*25.6±1.6*	

Table.3: Mean Indoor and Outdoor Air CO_2 Concentration across the five local governments (ppm).

	Location	Air CO_2 (ppm)						
		Morning			Afternoon			
		Min	Max	Mean±SD	Min	Max	Mean±SD	ASHRAE Limit
Indoor	Ibadan North	*244.0*	*419.0*	*337.9±57.8*	*316.0*	*446.*	*355.0±45.7*	1000
	Ibadan Northwest	*251.5*	*476.0*	*363.5±75.3*	*288.0*	*473.*	*356.2±62.5*	
	Ibadan Northeast	*268.0*	*511.5*	*377.4±83.3*	*284.5*	*439.*	*352.0±54.7*	
	Ibadan Southwest	*257.5*	*378.0*	*326.5±44.7*	*260.5*	*393.*	*326.2±41.2*	
	Ibadan Southeast	*262.0*	*472.5*	*371.6±79.6*	*299.0*	*356.*	*321.7±19.8*	
Outdoor	Ibadan North	*240.*	*476.0*	*358.5±82.1*	*323.*	*502.*	*409.2±2.3*	
	Ibadan Northwest	*239.*	*394.0*	*327.9±56.0*	*330.*	*490.*	*395.5±56.3*	
	Ibadan Northeast	*246.*	*384.5*	*326.8±51.9*	*347.*	*380.*	*370.0±10.8*	
	Ibadan Southwest	*250.*	*470.5*	363.6±*80.8*	*336.*	*514.*	*424.5±66.5*	
	Ibadan Southeast	*240.*	*384.*	*311.3±45.5*	*339.*	*371.*	*355.0±10.7*	

Table 4: Mean Indoor and outdoor Concentration of PM_{10} across the five local governments (μg/m^3).

	Location	Air PM_{10} (μg/m^3) Morning			Afternoon			WHO limits
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	*6.4*	*10.3*	*7.2±1.1*	*7.2*	*9.6*	*7.2±9.6*	50
	Ibadan Northwest	*7.2*	*9.6*	*7.2±9.6*	*6.8*	*9.8*	*7.8±0.9*	
	Ibadan Northeast	*6.9*	*9.9*	*7.6±9.6*	*7.1*	*9.9*	*8.0±0.9*	
	Ibadan Southwest	*6.8*	*9.3*	*7.2±0.8*	*7.2*	*9.8*	*8.0±0.8*	
	Ibadan Southeast	*6.8*	*9.7*	*7.5±1.2*	*7.0*	*9.8*	*7.9±0.9*	
Outdoor	Ibadan North	*5.8*	*10.2*	*7.4±1.6*	*6.1*	*10.3*	*8.0±1.9*	
	Ibadan Northwest	*5.9*	*10.2*	*7.7±1.6*	*5.9*	*10.5*	*7.7±1.9*	
	Ibadan Northeast	*5.9*	*10.3*	*7.7±1.5*	*6.1*	*10.6*	*7.9±1.7*	
	Ibadan Southwest	*5.8*	*10.2*	7.6±1.5	*6.3*	*10.4*	*8.0±1.7*	
	Ibadan Southeast	*5.8*	*10.2*	*7.7±1.5*	*6.1*	*10.6*	*7.8±1.7*	

Table 5: Mean Total Bacterial Counts (TBC) of the laundries among the five local governments (CFU/m^3).

	Location	Air microbial quality (CFU/m^3)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	66.5	91.0	82.9±9.0	72.5	91.0	82.8±6.1	≤5x10^2
	Ibadan Northwest	129.5	158.0	141.4±10.2	142.5	161.	155.7±6.3	
	Ibadan Northeast	79.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4	
	Ibadan Southwest	147.0	188.5	163.9±12.6	169.5	196.	183.7±8.9	
	Ibadan Southeast	75.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4	
Outdoor	Ibadan North	77.5	144.0	104.0±23.1	68.5	170.	120.4±4.6	
	Ibadan Northwest	132.0	180.5	153.4±16.2	144.5	181.	161.2±12.9	
	Ibadan Northeast	68.5	97.0	84.8±9.0	81.5	149.	91.9±20.0	
	Ibadan Southwest	147.0	188.5	163.9±12.6	169.5	196.	183.7±8.9	
	Ibadan Southeast	79.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4	

3.2 Microbial burden

3.2.1 Indoor and outdoor airborne Bacterial burden among five local governments.

Table 5 displays the average total bacterial counts (TBC) CFU/m3 indoor and outdoor values for the chosen laundry buildings. The mean total bacterial counts (TBC) CFU/m3 values for both the indoor and outdoor environments were significantly lower than the 5x102 CFU/m3 recommended guideline limit of the WHO, clean air act (CAA) of the United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) standards.

4.0 CONCLUSION

IAQ appeared to be impaired in the laundry environment in the Nigerian city of Ibadan. To maintain thermal comfort parameters and lower levels of chemical pollutants released by launderers and product use during services, mechanical ventilation systems in the laundry environment need to be upgraded with regard to operation and maintenance.

All of the laundries had relative humidity levels above the WHO, clean air act (CAA) of the United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) standards of 60%, which may be explained by the fact that the study was carried out in the morning and afternoon. The temperature and relative humidity were all over the permitted limits, despite the adequate sanitation practices, which caused the wastes and water to have an impact on interior air quality. All laundries visited had significantly lower PM_{10} levels than the WHO, clean air act (CAA) of the United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) guideline limit of 50 g/m^3. This demonstrates that the laundries have enough ventilation and that the outdoor CO_2 has a favorable impact on the indoor CO_2. The morning and afternoon indoor and outdoor meteorological conditions exceeded the WHO, clean air act (CAA) of the United Nations Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD), and the National Health and Medical Research Council (NHMRC) guideline limit of 18oC-26oC but this may be as a result of weather conditions in Nigeria. [25].

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

RECOMMENDATIONS

The following recommendations are given based on the research findings and these include programs that change the behavioural patterns of the launderers;

1. The causes and effects of indoor air pollution where laundry workers are employed should be disclosed to them in order to know how the ventilation system that may impact them should operate properly and/or to take steps to lessen their staff expression.
2. It's crucial to properly clean any areas that have accumulated water or had leaks as well as sources of microbiological pollutants (such as roofs, HVAC cooling coils, and fan coil units, if any). Additionally, quick removal of porous organic materials

(moulded ceiling tiles, carpets that have mildew, moist insulation in ventilation systems) should be promoted.

3. To ensure optimum work efficiency, employees of the National Environmental Standards and Regulations Enforcement Agency (NESREA) and the Environmental Health Officers Registration Council of Nigeria (EHORECON), Oyo State Chapter, should routinely monitor the indoor air quality in the laundry facilities every two years.
4. To regulate bio-aerosol concentrations, the laundry facilities' floors should be frequently mopped with biocides and bacillocide.
5. To encourage clean and sanitary environments, the association of launderers in Oyo State could impose weekly and monthly environmental sanitation to their members.

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